

### Comments

The enclosed is responsive to the Examiner's Office Action mailed September 21, 2006. At the time the Examiner mailed the Office Action claims 5-11 and 23-52 were pending. By way of the present response the Applicant has: 1) amended claims 5, 23 and 38; 2) added no new claims; and 3) has canceled claims 29-37 and 44-52 to expedite the advancement of the present applications. As such claims 5 -11, 23-28 and 38-43 remain pending. The Applicants respectfully request reconsideration of the present application and the allowance of all claims.

### 35 U.S.C. §101 REJECTIONS

Independent claims 5, 23 and 38 were rejected under 35 U.S.C. §101 as failing to be directed to statutory subject matter. Although the Applicant disagrees with the Examiners analysis of 35 U.S.C. §101, the Applicant has amended each independent claim to include storing matter onto a machine readable medium so as to be available for use by a geometric problem solver. The Applicant respectfully submits that the claims as presently presented should be deemed statutory by the Examiner.

### 35 U.S.C. §103 REJECTIONS

Independent claims 5, 23 and 38 are rejected under 35 USC §103(a) as being unpatentable over Shao-Po et al., "A Parser/Solver for Semidefinite Programs with Matrix Structure", Technical Report, Information System Laboratory, Stanford University, November 1995 (hereinafter "Shao-Po"), in view of Hershenson et al., US Patent No. 6,311,145 (hereinafter "Hershenson"), and Application No. 09/752,541  
Amdt. dated Mar. 21, 2007  
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further in view of Dennis Bricker, "Signomial Geometric Programming", University of Iowa, April 1999 (hereinafter "Bricker").

The Applicant has amended each of the independent claims to further characterize the "signomial" aspect of the claimed subject matter. Specifically, Shao-Po pertains to "semidefinite" and "max-det" problems while the Hershenson reference pertains to "geometric program" problems. One of ordinary skill in the art, as discussed at length immediately below, can readily distinguish between "signomial" problems and "semidefinite/max-det" problems or "geometric programs" because signomial problems contemplate the use of variable exponent values other than one (which semidefinite/max-det problems do not) and negative constraint coefficients (which geometric problems do not).

Thus, the Applicants' claimed limitation of (emphasis added)

at least one of said signomial expressions having a constraint with a negative coefficient value and an optimization variable with an exponent value that is not one

results in the Shao-Po and Hershenson references being inapplicable against the Applicants' claims. The Bricker reference is of no weight with respect to the patentability of the applicants' claims because it does not discuss any practical use of signomials. The essence of Bricker is provided immediately below in the comparison of signomials against semimidefinite/max-det problems and geometric programs

#### **Shao-Po solver/parser (SDP and max-det problems)**

Shao Po describes the implementation of a solver/parser for a special type of convex problems, namely, SDPs (semidefinite programs) and max-det problems.

Notice that since SDPs are a special case of max-det problems, we will just refer to max-det problems.

A max-det problem is defined as follows:

A *determinant maximization* (max-det) problem has the form

$$\begin{aligned} & \text{minimize} && c^T x + \sum_{i=1}^K \log \det G^{(i)}(x)^{-1} \\ & \text{subject to} && G^{(i)}(x) \succ 0, \quad i = 1, \dots, K \\ & && F^{(i)}(x) \succ 0, \quad i = 1, \dots, L \\ & && Ax = b, \end{aligned} \tag{1}$$

where the optimization variable is the vector  $x \in \mathbf{R}^m$ . The matrix functions  $G^{(i)} : \mathbf{R}^m \rightarrow \mathbf{R}^{l_i \times l_i}$  and  $F^{(i)} : \mathbf{R}^m \rightarrow \mathbf{R}^{n_i \times n_i}$  are affine:

$$\begin{aligned} G^{(i)}(x) &= G_0^{(i)} + x_1 G_1^{(i)} + \dots + x_m G_m^{(i)}, \quad i = 1, \dots, K \\ F^{(i)}(x) &= F_0^{(i)} + x_1 F_1^{(i)} + \dots + x_m F_m^{(i)}, \quad i = 1, \dots, L \end{aligned}$$

where  $G_j^{(i)}$  and  $F_j^{(i)}$  are symmetric for  $j = 0, \dots, m$ . The inequality signs in (1) denote matrix inequalities. We call  $G^{(i)}(x) \succ 0$  and  $F^{(i)}(x) \succ 0$  *linear matrix inequalities* (LMIs) in the variable  $x$ . Of course the LMI constraints in (1) can

be combined into one large block-diagonal LMI with diagonal blocks  $G^{(i)}(x)$  and  $F^{(i)}(x)$ .

Notice the following:

1. Optimization variables  $x_i$  are real variables that can take any real value between  $-\infty$  and  $+\infty$
2. The inequalities in this problem are linear matrix inequalities (LMIs) that pose a convex constraint on  $x$ . Note, however, that the exponent on the  $x$  variables is always one (thus the name linear). Also notice that the matrices  $G(i)$  and  $F(i)$  must be symmetric matrices (which is a substantial restriction on the problem).

## Hershenson reference geometric program (GP)

Hershenson notices that analog circuit design problems can be posed as another special type of convex optimization problems, namely a geometric program. A geometric program is defined as follows:

A *geometric program* (GP) is an optimization problem of the form

$$\begin{aligned} & \text{minimize} && f_0(x) \\ & \text{subject to} && f_i(x) \leq 1, \quad i = 1, \dots, m, \\ & && g_i(x) = 1, \quad i = 1, \dots, p, \end{aligned} \tag{3}$$

where  $f_i$  are posynomial functions,  $g_i$  are monomials, and  $x_i$  are the optimization variables. (There is an implicit constraint that the variables are positive, *i.e.*,  $x_i > 0$ .) We refer to the problem (3) as a geometric program in *standard form*, to distinguish it from extensions we will describe later. In a standard form GP, the objective must be posynomial (and it must be minimized); the equality constraints can only have the form of a monomial equal to one, and the inequality constraints can only have the form of a posynomial less than or equal to one.

Let  $x_1, \dots, x_n$  denote  $n$  real positive variables, and  $x = (x_1, \dots, x_n)$  a vector with components  $x_i$ . A real valued function  $f$  of  $x$ , with the form

$$f(x) = cx_1^{a_1}x_2^{a_2} \cdots x_n^{a_n}; \tag{1}$$

where  $c > 0$  and  $a_i \in \mathbb{R}$ , is called a *monomial function*, or more informally, a *monomial* (of the variables  $x_1, \dots, x_n$ ). We refer to the constant  $c$  as the *coefficient* of the monomial, and we refer to the constants  $a_1, \dots, a_n$  as the *exponents* of the monomial. As an example,  $2.3x_1^2x_2^{-0.15}$  is a monomial of the variables  $x_1$  and  $x_2$ , with coefficient 2.3 and  $x_2$ -exponent  $-0.15$ .

A sum of one or more monomials, *i.e.*, a function of the form

$$f(x) = \sum_{k=1}^K c_k x_1^{a_{1k}}x_2^{a_{2k}} \cdots x_n^{a_{nk}}, \tag{2}$$

where  $c_k > 0$ , is called a *posynomial function* or, more simply, a *posynomial* (with  $K$  terms,

Notice the following (in special as it is different from max-det problems  
considered by Shao-Po)

1. Optimization variable  $x$  is restricted to be real and positive. In other words  
it must take values that are between 0 and  $+\infty$ .

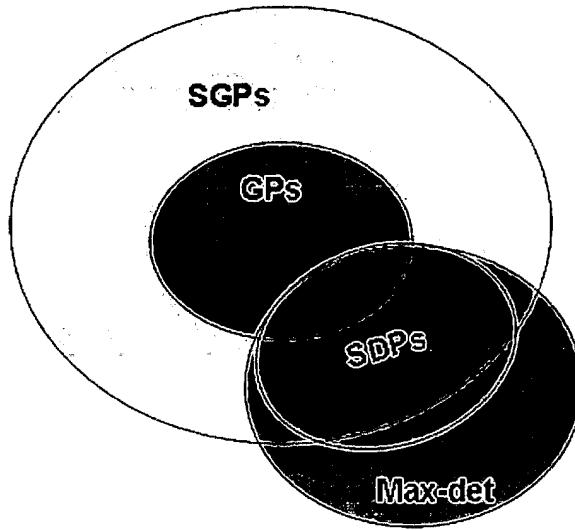
2. Posynomial/monomial constraints allow the variables to be raised to any real exponent (as opposed to being restricted to a one exponent in max-det problems)
3. Posynomial/monomial constraints restrict coefficients of the constraints to be positive, however no special constraints on symmetry must be considered. In particular there are no matrix constraints in geometric programs the same that they appear in max-det problems.

### Signomial program (SGP)

A signomial program has the same form as a geometric program except the coefficients in the posynomials can take any real value, i.e., they are not restricted to be positive.

Even though this seems like a small change in the problem form, it is in fact, a significant difference since it makes the problem a non-convex problem, and thus it makes the problem extremely difficult to solve globally (as opposed to a GP or a max-det problem which are convex problems and can be solved easily).

In summary, the space for the three problems can be defined as follows:



### **SGP: Signomial Programming**

Constraints: signomial (posynomial with real coefficients, real exponents)

Objective: signomial (posynomial with real coefficients, real exponents)

Variables: positive

### **GP: Geometric program**

Constraints: posynomial with positive coefficients, real exponents)

Objective: posynomial with positive coefficients, real exponents

Variables: positive

### **SDPs: Semidefinite program**

Constraints: Linear matrix equalities (symmetric matrices)

Objective: Linear

Variables: real

### **Max-det problems**

Constraints: Linear matrix equalities (symmetric matrices)

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Atty. Docket no. 4363.P001

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Objective: Linear plus log/det

Variables: real

In view of these arguments the Applicant respectfully submits that the pending claims are patentable and respectfully requests the allowance of the same.

### Conclusion

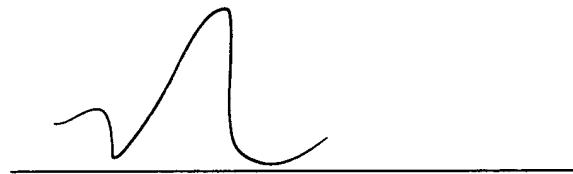
Applicant respectfully submits that all rejections have been overcome and that all pending claims are in condition for allowance.

If there are any additional charges, please charge Deposit Account No. 02-2666. If a telephone interview would in any way expedite the prosecution of this application, the Examiner is invited to contact Robert B. O'Rourke at (408)720-8300.

Respectfully Submitted,

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